A Systematic Review and Analysis of Palmer Type I Triangular Fibrocartilage Complex Injuries: Outcomes of Treatment

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Abstract

Triangular fibrocartilage complex (TFCC) injuries can present incidentally as an asymptomatic lesion or can cause acute and chronic pain. This study compared different treatment approaches for symptomatic Palmer Type 1 TFCC injuries and rates of improvement using a systematic review of the literature. Two hundred thirty-one articles were identified, 43 met criteria and were included. Two of these articles indicated conservative therapy may be adequate. Patients who underwent debridement for any Type 1 Palmer class returned to work at a rate of 92% (*n* = 182), but only 44% (*n* = 38) were free of pain. For 1B lesions that underwent repair, 68.3% (*n* = 226) were able to return to work and 41% (*n* = 52) had persistent pain. 1D lesions were treated with both repair and debridement with similar results. Data for Types 1A and 1C were limited as no authors solely addressed these lesions. For 1A lesions, those treated with traditional treatment of debridement still had high rates of being unable to return to work. The literature remains insufficient, making comparison between studies and techniques difficult. For asymptomatic injuries, there is no need for treatment. For patients with recalcitrant symptoms, surgery improves pain, grip strength, and increases return to work and activity. The level of evidence is IV.

Keywords
- TFCC
- open repair
- arthroscopic repair
- conservative management
- wrist pain

Introduction

The triangular fibrocartilage complex (TFCC) acts in forearm rotation as the primary stabilizer of the distal radioulnar joint (DRUJ)[1] while also providing a smooth articular surface and partially absorbing the axial load from the radiocarpal joint.[2] Given its anatomical complexity and functional role in rotation and load bearing, it becomes a vulnerable structure both for traumatic injuries and for degeneration.[3]

In 1989, Palmer classified TFCC lesions based on their mechanism, either traumatic or degenerative, and their location. 1A lesions are central, 1B lesions are ulnar, 1C lesions are distal avulsions, and 1D lesions are radial sided (►**Table 1**).[4] Although Palmer's goal with classification was to aid in the creation of a treatment algorithm, literature to date has been complicated by small studies, assorted techniques, lack of standardized scoring metrics, and incorporating multiple Palmer classes under treatment algorithms. Additionally, TFCC injuries may be asymptomatic[5-7] and with central lesions, it can be difficult to distinguish between traumatic versus degenerative.[8] This has led to difficulty in determining clear treatment algorithms for each class of injury.

TFCC injuries can present incidentally as an asymptomatic lesion or the same injury pattern can cause acute and chronic pain. The goal of this study was to compare different approaches for treatment of Palmer Type 1 TFCC injuries and rates of improvement as categorized by the sites of TFCC injury utilizing a systematic review of Palmer Type 1 TFCC injuries.

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Table 1 Palmer classification

Type 1 injuries: traumatic	
Type 1A	Central tear
Type 1B	Ulnar avulsion (± ulnar styloid fracture)
Type 1C	Distal avulsion
Type 1D	Radial avulsion (± sigmoid notch fracture)

Materials and Methods

A systematic review of the current literature dealing with Palmer Type 1 lesions was performed. Each publication was reviewed and the following data were collected: author(s), publication year, study design, Palmer classification, repair type, demographics of study cohort, time to intervention, follow-up time, postoperative pain, function, and work status.

A database search of Ovid MEDLINE and PubMed using keywords "TFCC," "triangular fibrocartilage complex," "outcomes," "conservative management," "arthroscopic," "open," and "repair" was completed. Updates were performed to include newly published studies that met inclusion criteria. A bibliographic review of included articles was also performed to identify other potentially relevant publications.

Studies published between 1990 and 2019 were reviewed. Full-text articles with adult patients sustaining TFCC tears and postoperative outcome measures, both subjective and objective, were included. We excluded non-English articles, nonadult cohorts, animal studies, cadaver studies, and studies that had significant concomitant injuries that did not establish controls for isolated TFCC injuries, studies in which Palmer classification was not explicitly enumerated or obvious from text language, and studies which focused on Palmer Type 2 or degenerative lesions. Reinjury, revisions, surgical technique, and expert opinions were also excluded.

If an abstract was not available or enough information was obtained from the title and abstract to apply the exclusion criteria, the full text was reviewed. Overall, 231 articles were identified through the database search. Of these, 43 were determined to be relevant and included in the qualitative synthesis (►**Supplementary Appendix**, available in the online version).

Results

Nonoperative Treatment

Nonoperative management of acute TFCC injuries commonly includes activity modification, immobilization, anti-inflammatory medications, steroid injections, and physiotherapy. Ten authors gave the predicate length of conservative management prior to intervention. Miwa et al proceeded to surgery after 2 months with persistent "unendurable pain."[9] Tang et al,[10] Kim et al,[11] Sarkissian et al,[12] and Iwasaki et al[13] all moved to surgery after 3 months with Iwasaki et al using a removal wrist brace for immobilization. Ruch and Papadonikolakis[14] and Infanger and Grimm[15] proceeded after at least 4 months of conservative management and Papapetropoulos et al,[16] Bayoumy et al,[17] and Millants et al[18] utilized 6 months of conservative management with splinting and anti-inflammatories prior to surgical intervention.

To date, there have been no studies examining isolated TFCC injuries managed entirely nonoperatively. The closest available data are derived from TFCC injuries associated with distal radius fractures (DRFs)[19,20] in which the radius is treated per routine operative intervention and the TFCC is not directly intervened on. In this injury group, it has been shown that TFCC tears can been detected in up to 80% of patients with displaced fractures.[20-22] Deniz et al obtained magnetic resonance imaging (MRI) from 47 consecutive DRF patients treated conservatively with closed reduction and casting. TFCC injury was detected in 24 (51%) of the patients (Type 1A 5, Type 1B 17, Type 1C 1, and 1 complex tear). At an average of just more than 3 years, no difference in Mayo wrist score was noted between patients with and without TFCC injury and 21 had an excellent result, 16 reported a good result, and 10 reported satisfactory.[19]

Mrkonjic et al[20] reported the long-term follow-up[23,24] of 51 adults with DRFs in which the fractures were operatively managed, and 43 concomitant TFCC injuries were managed with immobilization per their routine fracture management. Patients were followed up for 13 to 15 years and among the 38 patients who completed follow-up, only 1 patient noted ongoing ulnar-sided wrist pain that subsequently underwent operative repair of the TFCC, though no follow-up on that patient was provided. Though pain was improved in the other 37 patients, those who had minor instability of the DRUJ (17/38, 45%) at initial presentation had significantly worse grip strengths than those with stable DRUJ at final follow-up (83 vs. 103% of contralateral side, $p = 0.03$).

These two small studies as well as a case study reporting full recovery of a single type 1B injury with 12 weeks of bracing[25] indicate that conservative therapy may be adequate for the treatment of TFCC injuries. However, these data are limited by confounding injury and the absence of controlled outcome comparison studies. Additionally, as the conservative treatment literature is frequently based on concomitant injury such as DRF, it is unclear if the TFCC injury was symptomatic, or if the DRUJ was unstable secondary to fracture morphology or direct injury to the substance of the TFCC.

Operative Treatment

In the operative outcomes evaluated by this study, the average time to intervention was 9 months (range: 4–18 months). Many articles suggested that the decision to proceed with surgery was made after failure of conservative therapy, with persistent pain and the patient's inability to work or resume normal activities. In a retrospective review of patients clinically identified as having a TFCC injury and treated conservatively, Park et al noted that out of 84 patients, 36 did not have resolution of symptoms and required further imaging and subsequent surgical intervention (43%).[26]

Debridement

When conservative management fails to improve ulnar-sided wrist pain, many surgeons proceed with debridement of the

Table 2 Results of debridement

Debridement	
Total patients	302
1A	178
1B	55
1C	14
1D	27
Uncategorized	37 Some patients had multiple sites of injury
Average age	35 y
Average time from injury to intervention	8 mo
Average follow-up	58 mo
Free of pain	44.7% (38/55)
Persistent pain	55.2% (47/55)
Unchanged pain	8% (7/85)
Returned to work	93% (182/196)

central TFCC disc. This therapy is largely based on data from both Palmer et al[27] and Adams and Holley,[28] showing that up to 80% of the central disc can be debrided safely without affecting biomechanics of the radiocarpal joint or DRUJ (►**Table 2**).

In this analysis, 302 patients underwent TFCC debridement in 10 articles of a variety of Palmer types (178 1A, 53 1B, 14 1C, 28 1D with 43 unclassified Type 1) which were not separated for results and sometimes represent multiple lesions in the same patient.[9,15,29-36] All were done arthroscopically. Three of these articles used the Mayo wrist classification to evaluate patient outcomes, and among the 75 patients in these studies, 30 patients demonstrated excellent, 29 good, 9 fair, and 7 poor outcomes. Eighty-five of the patients had data recorded regarding pain outcomes and 38 (44.7%) were free of pain at final follow-up (average: 101 months, median: 39 months), 24 (28%) were much better or had mild pain, 8 (9.4%) somewhat better or had moderate pain, and 7 (8.2%) remained unchanged or had severe pain. Eight patients continued to have pain but it was not categorized. One hundred ninety-six patients had available outcomes regarding return to work or sports, with a rate of 92% (n = 35) returning to preinjury function and work status.

Repair

In comparison to central TFCC injuries, the well-vascularized perimeter of the TFCC[37] is theorized to allow improved healing, both primarily and following surgical reconstruction. As such, the majority of operative treatment for peripheral injuries is based more on suture repair as opposed to limited debridement.

In our review, 16 articles were found focusing specifically on outcomes of arthroscopically repaired 1B lesions with a total of 409 patients undergoing repair.[11-13,16-18,38-47] For the 16 articles, four different scoring metrics were reported (Disabilities of the Arm, Shoulder, and Hand [DASH], Mayo, visual analog scale, and personal scoring system) and not every article reported pre- and postoperative values. Additionally, not all reported range of motion (ROM), pain, or return to work status. DASH score was the most reported with an overall average improvement from 40.2 to 14.8 in 10 articles.[12,13,17,18,40,42,44-47] Return to work was the second most common outcome discussed in eight of the articles,[13,18,39-43,46] showing that in this group with an average age of 33, only 68% were able to return to work. Six articles specifically addressed pain[13,18,38,41,42,45] of the patients, persistent pain was noted in 52 (40.9%), though an additional 34 were noted to have a "reduction in pain" which was not specified regarding full resolution.

Isolated distal (Type 1C) and radial (Type 1D) are uncommon. In our review, nine articles contained 39 1C lesions and these were treated with either suture repair or arthroscopic debridement. With debridement, Miwa et al[9] reported patient outcomes with four excellent, three good, one fair, and no poor results. Infanger and Grimm[15] treated four patients with laser debridement, and at follow-up of 25.6 months, three were pain free and one had mild pain. No authors using repair separated out their results specifically for 1C lesions making additional comparisons difficult.

For 1D lesions, some authors argue that peripheral tears on the radial side do not heal and should therefore be treated with debridement. Others advocate for suture repair, often anchoring the TFCC to the radius. Miwa et al directly compared suture versus debridement and noted with suture, four wrists were excellent, seven were good, none was fair, and one was poor based on the Minami categorization, whereas the debridement group had two excellent, two good, and one poor outcomes.[9] McAdams et al[35] also performed a repair of a 1D injury as well as a debridement and noted both were able to return to sports in 3 months. Tang et al[10] noted better repair results with the inside-out suture technique with ulnar styloid (1B) and sigmoid notch (1D) tears as compared with foveal lesions, overall showing three excellent, three good, six fair, and two poor results by Mayo classification. However, in a second article describing a new technique using a double-armed suture and using 1A, 1B, and 1D lesions, they reported two excellent, three good, and five fair outcomes. The five lowest scores, all "fair," were from 1D lesions.[48]

Ulnar Variance

TFCC injuries are often associated with an increase in ulnar variance. In ulnar neutral variance, Palmer and Werner showed that the ulna and TFCC bear 18% of the load, but with positive ulnar variance greater than 2.5 mm, 42% of the load shifts over the ulnar side.[49] Ulnar shortening reduces the radiocarpal axial load on the TFCC, and can concomitantly support DRUJ stabilization by tightening the TFCC ligaments via the distal oblique bundle of the interosseous membrane.

In 1991, Hermansdorfer and Kleinman[50] treated 11 chronic ulnar wrist pain patients with open reattachment of TFCC to the ulnar fovea. Of these, two of the three patients with

unsatisfactory outcomes had neutral and/or negative ulnar variances, and had pain relief after a secondary ulnar shortening procedure.

In 1996, Trumble et al[3] reported outcomes after arthroscopic repair of peripheral injuries with the anecdotal theory that ulnar positive and neutral wrists were more likely to have recurrence of symptoms within 1 year of TFCC repair. As such, patients who had ulnar positive or neutral variance with symptoms more than 1 year were determined as candidates for a simultaneous ulnar shortening osteotomy. Overall, 17 of the 21 patients (81%) had complete resolution of pain. Grip strength and wrist ROM (as an average of motions in all three different planes) averaged 82 and 86%, respectively, of the contralateral side. The type of injury, age, gender, or additional injuries did not appear to affect the outcomes. However, delay in surgery in months had a significant, linearly negative correlation with both grip strength and ROM outcomes. Ruch and Papadonikolakis also found a strong correlation between increased DASH scores (worse functional outcomes) and positive ulnar variance in their 35 Type 1B injury case series with TFCC repair based on the outside-in technique.[14]

In 2008, Reiter et al described an arthroscopic inside-out technique to repair 46 Type 1B lesions and reported comparable outcomes with previous studies.[42] However, they did not find any correlation between DASH scores and positive or neutral ulnar variance and a delay to surgery did not affect grip strength, ROM, or pain relief outcomes unlike previous studies.

Finally, Wolf et al evaluated 49 patients with 1B tears who underwent arthroscopic repair and evaluated them for short-term results (average of 11 months) and long-term (average of 57.6 months) results (►**Table 3**). At short-term follow-up, six patients continued to have ulnar-sided wrist pain and elected to undergo ulnar shortening. This was performed at an average of 17 months after arthroscopic repair with a mean shortening of 3 mm. All patients had dynamic positive variance (1.4 mm), though 10 of the original patients also had this variance and did not require additional intervention.[44]

Table 3 Results of 1B interventions

Palmer 1B lesions	
Total patients	469
Arthroscopic repair	409
Open repair	29
Debridement	31
Average age	32 y
Average time from injury to intervention	12 mo
Average follow-up	32 mo
Free of pain	18% (23/127)
Persistent pain	41% (52/127)
Returned to work or activities	68% (154/226)

Overall, evidence supports that ulnar shortening osteotomies may be necessary for positive ulnar variance patients; however, this may be considered as a secondary procedure after failure of TFCC treatment.

Discussion

Disruptions of the TFCC do not always present clearly or along a discrete timeline. Many TFCC lesions can be identified on advanced imaging while being asymptomatic to the patient. In an evaluation of asymptomatic volunteers, Kirschenbaum et al identified six TFCC lesions in the arthrogram of 52 asymptomatic adults.[5] Iordache et al took 103 asymptomatic volunteers and showed that 39 TFCCs were abnormal with 23 full tears on MRI. They also found that TFCCs in patients older than 60 years were universally abnormal, and there was a correlation with increasing age and severity.[6] In 977 asymptomatic, symptomatic, and cadaver wrists, prevalence increased from 27% in patients younger than 30 years to 49% in those older than 70 years.[51] Finally, Brown et al also examined contralateral wrists to injury, finding perforated TFCCs in 59% of symptomatic and 19% of asymptomatic wrists.[7]

The high prevalence of asymptomatic lesions, as well as the studies on nonoperative management with successful results of incidentally identified lesions in the setting of other injuries, may indicate that TFCC lesions can be treated conservatively. Additionally, recent studies indicate there may be variable or nonexistent nervous innervation to the region. Gupta et al showed, via nitric acid stain, that in nine cadaver wrists, there was no innervation to regions correlating to 1A and 1D lesions. 1C areas were innervated by branches of the ulnar and the dorsal sensory branch in all specimens and 1B in five of the nine specimens.[52] Unglaub et al theorized that pain could come from ingrowth of nerve fibers secondary to trauma. However, when they investigated 1A lesions, none of the 32 patients showed ingrowth of fibers in biopsy stains.[53]

The literature to date however does support that a portion of patients treated conservatively continue to have pain and are unable to return to activities or work. Park et al reported this number as high as 43%,[26] but no other articles discuss the prevalence of work restriction or agree on the length of time to trial conservative therapy.

The question then becomes how best to manage symptomatic lesions. Thiru et al's cadaver study showing vascularity only existing in the outer 15 to 20%[37] is the physiologic foundation on which current TFCC treatment is based. Additionally, both Palmer et al[27] and Adams and Holley[28] showed that 80% of the disc can be debrided safely without affecting biomechanics of the wrist. Debridement has therefore become the answer for central (1A) lesions due to this lack of vascularity and proposed lack of healing. However, in the review, no articles separated out 1A lesions individually for comparative outcomes. Overall, for debridement, although 44% were free of pain, 8% were unchanged and 55% had some level of persistence. Additionally,

8% in a group that's average age was 35 years was unable to return to work remains a significant number. In another recent review of debridement only, 13% were unable to return to work, although there was significant variation in the articles cited with the variable of workers' compensation having significant influence.[54]

For peripheral injuries (1B, 1C, and 1D), arthroscopic repair of TFCC injuries has risen in popularity recently due to superior visualization of the TFCC and minimally invasive nature of the technique. Recently, several systemic reviews have compared open verses arthroscopic techniques for repair of 1B lesions and all have concluded that there was no difference in terms of ROM, grip strength, or functional outcome scores. However, each noted that very few high-quality studies had been performed and that all studies selected had methodological issues with a high risk of bias.[55-57] Miwa et al showed that in 1B and 1D lesions, arthroscopic suture repair restored anatomic continuity, was easy to perform, and had similar results to debridement. By the Minami evaluation, suture repair had 16 (47%) excellent, 15 good, 2 fair, and 1 poor results. Debridement had 16 excellent (36%), 10 good, 1 fair, and 1 poor results.[9]

Overall, there does not seem to be a remarkable difference between debridement and repair. Debridement was shown in all Palmer types to have an improvement in DASH scores, pain scores, and good return to work. For repair, there exists a plethora of techniques described with no significant difference found in the small articles comparing debridement to repair. Additionally, for patients with neutral or positive ulnar variance who have failed to improve following treatment for TFCC injuries, ulnar shortening osteotomy or debridement may offer additional improvements or pain relief.

In general, the literature remains insufficient with small retrospective studies, differing reporting metrics, inadequate reporting of preoperative versus postoperative outcome, a multitude of surgical techniques, and minimal stratification by Palmer classification, making comparisons difficult, as well as difficulty in fulfilling Palmer's goal of creating an evidence-based treatment algorithm based on his classification schema.

Conclusion

At this time, there remain three generalized treatment modalities no matter the injury type. For those that are asymptomatic or have incidentally identified TFCC injuries, no treatment is recommended. Conservative treatment with immobilization has been shown by several authors to have a relatively high success rate among all Palmer types, either precluding the need for intervention or reducing the percentage that requires it. For those patients with recalcitrant pain or instability, surgery improves pain, grip strength, and increases return to work and activities. Although we found a significant amount of focus in the literature on discussing TFCC injuries, unfortunately, the heterogeneity of inputs made statistical analysis ineffective. Throughout the literature, in a population with an average age in the early 30s and a diminished preoperative grip strength, there remains a significant number with pain or disability precluding a return to work no matter the type of intervention, and therefore, no specific type of intervention can be recommended based on the Palmer type. There clearly remains a need for multi-institutional controlled randomized studies to create a high-quality evidence-based algorithm for different TFCC injuries.

Note

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. government.

Conflict of Interest

None declared.

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